

## **WALNUT RIVER BASIN TOTAL MAXIMUM DAILY LOAD**

### **Water Body: El Dorado Lake Water Quality Impairment: Siltation**

**Subbasin:** Upper Walnut

**Counties:** Butler and Chase

**HUC 8:** 11030017

**HUC 11 (HUC 14):** **030** (010, 020, 030, 040, 050, 060)

**Ecoregion:** Flint Hills (28)

**Drainage Area:** Approximately 241.9 square miles.

**Conservation Pool:** Area = 7,467 acres  
Watershed Area: Lake Surface Area = 18:1  
Maximum Depth = 15.5 meters (50.9 feet)  
Mean Depth = 6.3 meters (21 feet)  
Retention Time = 2.4 years (28.8 months)

**Designated Uses:** Primary and Secondary Contact Recreation; Expected Aquatic Life Support; Drinking Water; Industrial Water Supply Use; Food Procurement

**Authority:** Federal (U.S. Army Corps of Engineers), State (Kansas Water Office)

**1998 303d Listing:** Table 4 - Water Quality Limited Lakes

**Impaired Use:** Expected Aquatic Life Support and Primary and Secondary Contact Recreation

**Water Quality Standard:** Suspended solids - Narrative: Suspended solids added to surface waters by artificial sources shall not interfere with the behavior, reproduction, physical habitat or other factor related to the survival and propagation of aquatic or semi-aquatic or terrestrial wildlife. (KAR 28-16-28e(c)(2)(D)).

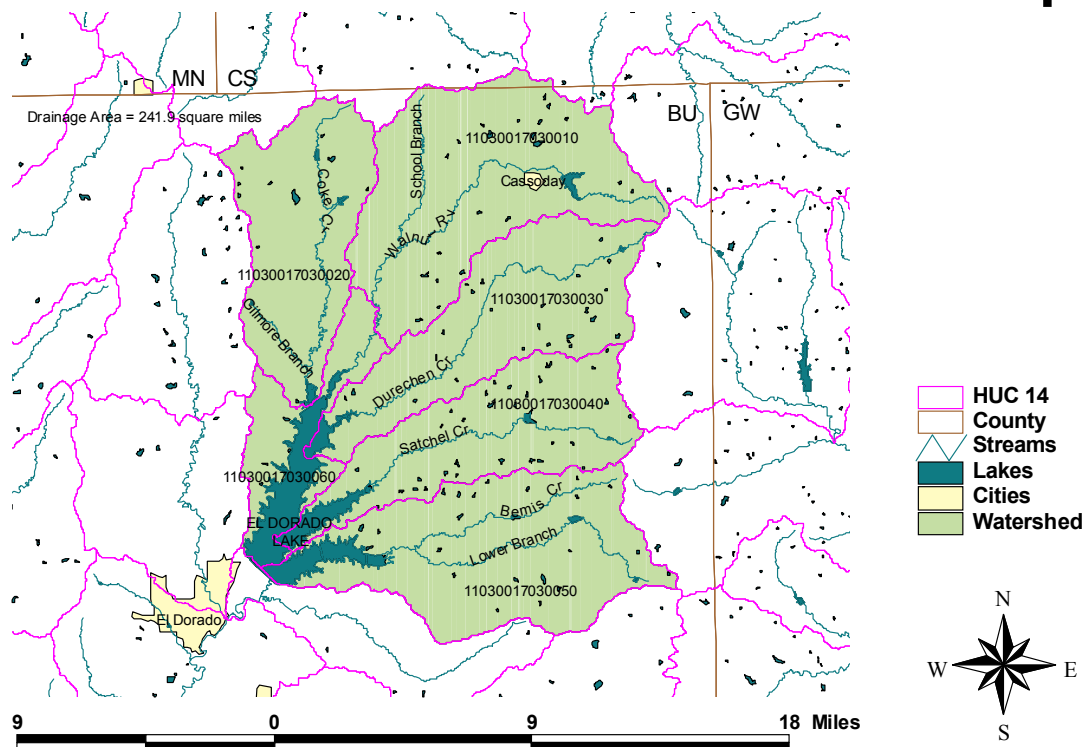
## **2. CURRENT WATER QUALITY CONDITION AND DESIRED ENDPOINT**

**Monitoring Sites:** Station 033001 in El Dorado Lake. (Figure 1)

**Period of Record Used:** Five surveys during 1987 - 1999 and Kansas Biological Survey (2000)

Figure 1

## El Dorado Lake TMDL Reference Map



**Current Condition:** Surface water in El Dorado Lake has high turbidity, dominated by inorganic materials because the lake receives a sporadic inflow of silt, associated with occasional runoff events in the Flint Hills comprising the lake's drainage area. The turbidity has increased over the period of record, notably in 1993, after major inflows occurred in May of that year. The 1993 and 1999 surveys were conducted after substantial spring runoff events. The lake is light limited (Appendix B). Based on samples taken by KDHE, the average transparency (Secchi Disc depth) is 58 cm, the average turbidity is 26.2 formazin turbidity units, and the average total suspended solid concentration is 17 mg/L (Appendix A and table below). Lakes are considered to have a siltation problem if they meet the following criteria: chronically turbid, trophic state index plots indicate light limitation, average chlorophyll a concentrations less than 7.2 ppb, and Secchi Disc Depth less than 0.5 meters. El Dorado Lake is deemed to be argillotrophic, as its average chlorophyll a concentration is 3.45 ppb (TSI = 42.7), while its average total phosphorus concentration is 75 ppb.

#### Averages of KDHE Lake Monitoring Samples

<b>DATE</b>	<b>Average Total Suspended Solids (mg/L)</b>	<b>Average Turbidity (formazin turbidity units)</b>	<b>Secchi Depth (m)</b>	<b>Maximum Lake Elevation in 30 days before survey</b>
9/9/87	8			
6/4/90		7.5	1.00	1339.72
6/2/93	23	30.5	0.50	1344.98
6/3/96	14	21.0	0.45	1335.80
6/22/99	21	46.0	0.35	1340.55

In 2000, the Kansas Biological Survey collected data monthly at ten stations (Figure 2) in El Dorado Lake. A summary of those results is included in the below table.

#### Averages of Kansas Biological Survey Samples at the Ten Stations

<b>Location</b>	<b>Average Total Suspended Solids (mg/L)</b>	<b>Average Turbidity (formazin turbidity units)</b>	<b>Secchi Depth (m)</b>
Walnut River Arm (Station 1) - Riverine	<b>39</b>	<b>90.8</b>	<b>0.41</b>
Walnut River Arm (Station 2) - Transitional	<b>25</b>	<b>47.9</b>	<b>0.49</b>
Walnut River Arm (Station 3) - Transitional	<b>22</b>	<b>41.2</b>	<b>0.54</b>
Walnut River Arm (Station 4) - Transitional	<b>21</b>	<b>41.7</b>	<b>0.64</b>
Satchel Creek Arm (Station 5) - Riverine	<b>25</b>	<b>54.2</b>	<b>0.51</b>
Satchel Creek Arm (Station 6) - Transitional	<b>22</b>	<b>35.8</b>	<b>0.52</b>
Main Basin (Station 7) - Lacustrine	<b>25</b>	<b>34.7</b>	<b>0.61</b>
Bemis Creek Arm (Station 8) - Lacustrine	<b>20</b>	<b>33.1</b>	<b>0.58</b>
Bemis Creek Arm (Stations 9) - Riverine	<b>41</b>	<b>56.4</b>	<b>0.32</b>
Bemis Creek Arm (Stations 10) - Transitional	<b>34</b>	<b>70.0</b>	<b>0.32</b>
Lake Average for 2000	<b>27</b>	<b>50.6</b>	<b>0.49</b>

From this data, it appears that the Walnut River subwatershed is making the greatest contribution to the turbidity of the lake. Bemis Creek is also a significant contributor to the sedimentation load.

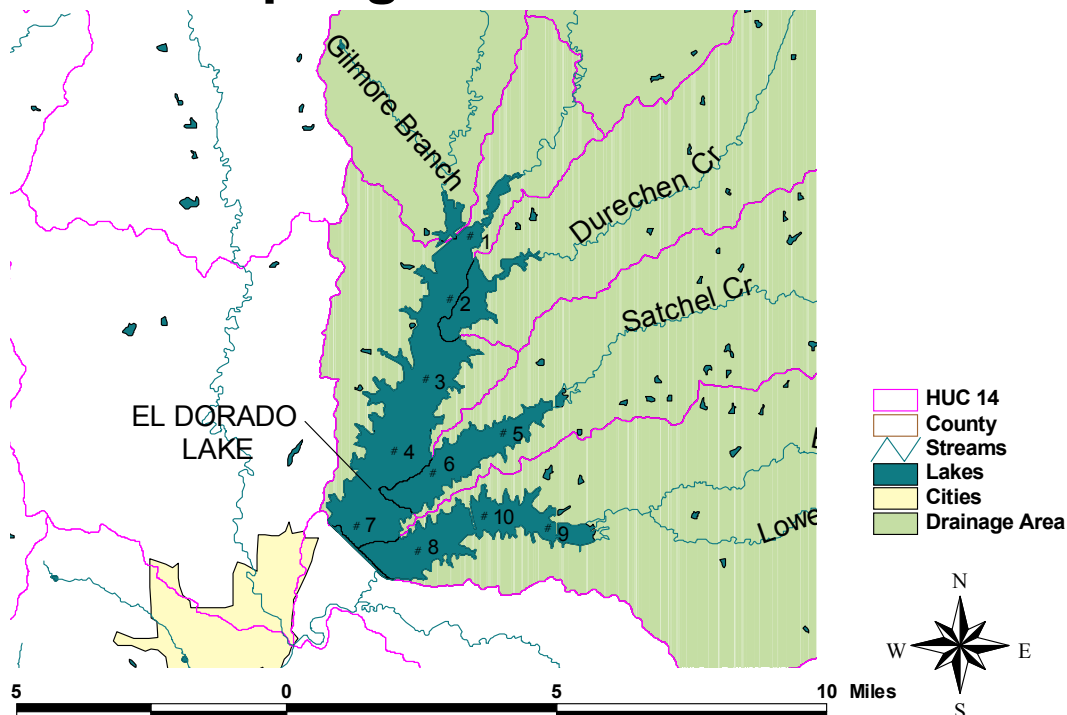
The data are converted to loads by the following method. To determine the inflow into both arms of the lake, the proportion of the subwatershed to the entire watershed was multiplied times the inflow data from the U. S. Army Corps of Engineers. The load was calculated by multiplying the subwatershed inflow times the average concentration times a conversion factor. From this calculation, it is evident that the Walnut River subwatershed is making the greatest contribution to the total suspended solids load. The Bemis Creek subwatershed is a secondary contributor; and the Satchel Creek subwatershed is a tertiary contributor.

### Loads Calculated from the Kansas Biological Survey Sample Data

Location - Zone	Drainage Area	Total Suspended Solids Load
Walnut River Arm (Station 2)	153 mi <sup>2</sup>	656 lbs/day
Satchel Creek Arm (Station 5)	37 mi <sup>2</sup>	158 lbs/day
Bemis Creek Arm (Stations 9)	52 mi <sup>2</sup>	368 lbs/day

**Figure 2**

## KBS Sampling Sites on El Dorado Lake



The reservoir construction was completed in 1981 and had a conservation storage capacity of 163,929 acre-feet. The subsequent survey was taken of the lake bathymetry in 1989, indicating a conservation storage capacity of 161,929 acre-feet. The loss of 2,000 acre-feet of storage over 8 years represents an average annual loss of 250 acre-feet per year. At an average annual rate of 250 acre-feet per year, the estimated life span of the lake would be 648 years.

The reservoir construction was completed in 1981 and had a conservation storage capacity of 163,929 acre-feet. The subsequent survey was taken of the lake bathymetry in 1989, indicating a conservation storage capacity of 161,929 acre-feet. The loss of 2,000 acre-feet of storage over 8 years represents an average annual loss of 250 acre-feet per year. The Tulsa District of the Corps of Engineers indicates the sediment storage of the lake is 17,400 acre-feet, designed to be filled over 100 years. At the initial rate of sedimentation, the sediment storage will be filled in

70 years.

### **Interim Endpoints of Water Quality (Implied Load Capacity) at El Dorado Lake over 2007 - 2011:**

In order to improve the quality of the water column, the endpoint for El Dorado Lake will be an increase in average transparency as measured by Secchi Disc Depth of 1 meter. Current turbidity impairments have reduced the current Secchi Disc depth to one-third of this endpoint, leading to an argillotrophic condition in the lake, which impedes primary productivity and dampens the support of aquatic life within the lake. Some reduction in phosphorus loading to the lake will be expected as a result of reducing sediment loads to the lake. Phosphorus is typically attached to sediment, and while the proportional reduction in phosphorus may be greater than that for sediment, simultaneous control of both pollutants should help the lake achieve its Secchi Disk Depth endpoint.

Sediment accumulation in the lake reduces the reservoir volume, and limits accessibility to portions of the lake which have silted in. Additionally, accumulated sediment contributes to recycling of nutrients within the lake. Therefore, reduction of the sediment accumulation rate improves the quality of the lake and extends the utility as a water supply and recreation facility. Given that the initial rate of sedimentation exceeded the design rate, the second endpoint shall be reducing the average sediment rate from 250 acre-feet per year, to 174 acre-feet per year, a 30 percent decrease. Assuming the initial rate of storage loss continued from 1989 to 2002, El Dorado Lake would have 158,679 acre-feet now. By 2011, at the initial rate, the storage would be 156,429 acre-feet. Under this TMDL, with a reduction in sediment rate, the anticipated storage in 2011 would be 157,113 acre-feet. For reference, if the lake had lost storage at its design rate since dam closure, the storage of the conservation pool would be 158,709 acre-feet.

Because of the inter-annual carryover feature of El Dorado storage, seasonal variation in the endpoint is not established by this TMDL. It can be anticipated that reduction in sediment loading to the lake will be most prevalent during the spring runoff events. This endpoint can be reached as a result of expected reductions in loading from the various sources in the watershed resulting from implementation of corrective actions and Best Management Practices, as directed by this TMDL. Achievement of the endpoints indicates loads are within expectations for the lake, therefore the narrative water quality standard pertaining to suspended solids would be attained.

### **3. SOURCE INVENTORY AND ASSESSMENT**

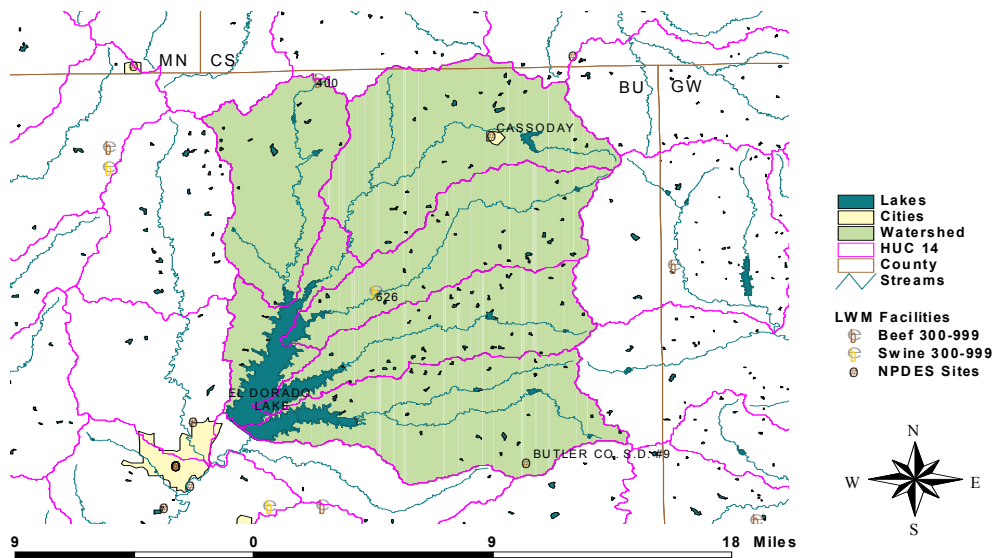
**NPDES:** Two permitted facilities are located within the watershed (Figure 3). Both are non-overflowing lagoons that are prohibited from discharging but may contribute some sediment load under extreme precipitation events (flow durations exceeded 1 - 5 percent of the time). According to projections of future water use and resulting wastewater, both look to have sufficient treatment capacity available.

### Waste Treatment Plants in the El Dorado Lake Watershed

Name	Type	Design Flow (MGD)	Expiration Date
Cassoday Wastewater Treatment Plant	3-cell lagoon	0.027	2006
Butler County Sewer District No. 9 Wastewater Treatment Facility	4-cell lagoon	0.0275	2006

**Figure 3**

### El Dorado Lake NPDES Sites and LWM Facilities



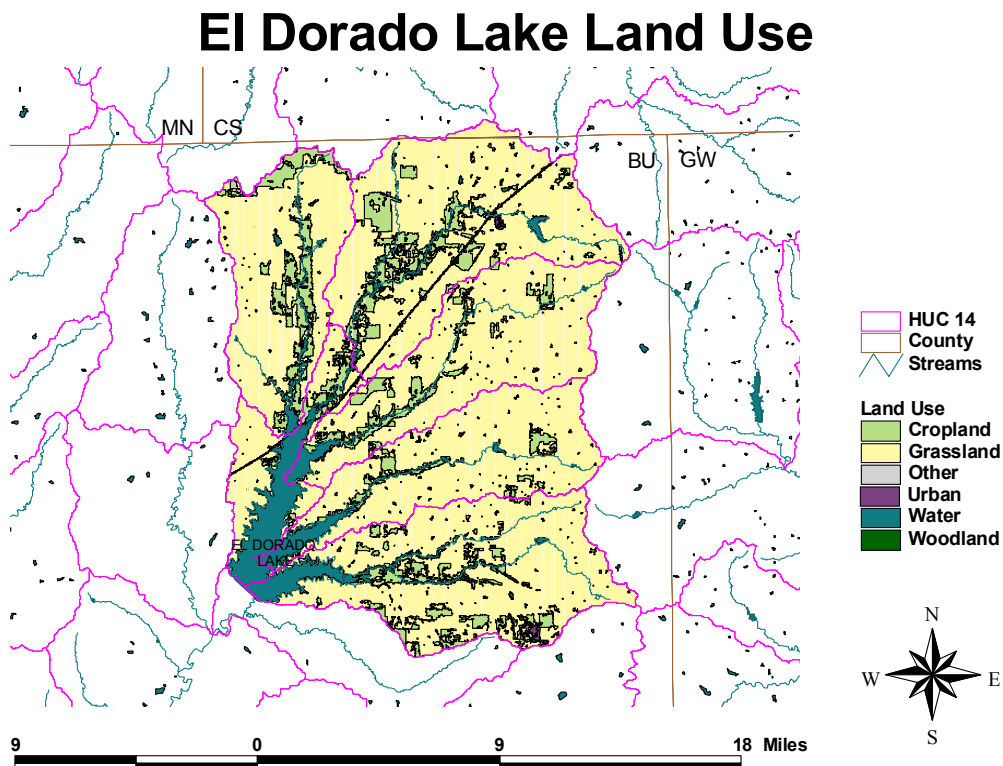
**Land Use:** The siltation impairment is most likely due to cropland that is adjacent to the streams that drain into El Dorado Lake. Soil from exposed land runs-off into the lake, increasing the turbidity and concentration of total suspended solids and decreasing the transparency. Land use coverage analysis indicates that 11.9% of the watershed is cropland, and 80.8 % is grassland (Figure 4). The Walnut River has the greatest amount of cropland (20.9 square miles), while there are 5.6 square miles of cropland in the Bemis Creek subwatershed and 2.2 square miles of cropland in the Satchel Creek subwatershed. More woodland and grassland buffers are needed around the streams to prevent erosion.

Sediment from urban land may get transported into the watershed. However, this source is probably not a major contributor because there is minimal urban land (less than 1% of the watershed) around the lake, and population projections for the county to the year 2020 indicate no growth in population. All of the urban land is located in the Walnut River (0.14 square mile) and Bemis Creek (0.17 square mile) subwatersheds.

**Contributing Runoff:** The watershed's average soil permeability is 0.5 inches/hour according to NRCS STATSGO database. About 99.1% of the watershed produces runoff even under relatively low (1.5"/hr) potential runoff conditions. Runoff is chiefly generated as infiltration excess with rainfall intensities greater than soil permeabilities. As the watersheds' soil profiles become saturated, excess overland flow is produced. Generally, storms producing less than 0.5"/hr of rain will generate runoff from 94.5% of this watershed, chiefly along the stream channels.

**Background Levels:** Carp may cause some resuspension of sediment. Background levels of total suspended solids come from stream channels. Sediment becomes suspended during high flow events as soil along the banks is eroded.

Figure 4



#### 4. ALLOCATION OF POLLUTANT REDUCTION RESPONSIBILITY

The goal of this TMDL is to reduce the current sedimentation rate to its original design rate, and therefore the Load Capacity of El Dorado Lake, from ~~is~~ 250 acre-feet per year to 174 acre-feet. Assuming a bulk density of the sediment of 58 pounds per cubic foot, the load capacity is about 220,000 tons per year. More detailed assessment of sources and confirmation of the sediment delivery must be completed before detailed allocations can be made. The general inventory of sources within the drainage does provide some guidance as to areas to focus load reduction.

**Point Sources:** A current Wasteload Allocation of zero is established by this TMDL because of the lack of discharging point sources in the watershed. Should future point sources be proposed in the watershed and discharge into the impaired segments, the current Wasteload Allocation will be revised by adjusting current load allocations to account for the presence and impact of these new point source dischargers. As previously noted in the inventory and assessment section, sources such as non-discharging permitted municipal facilities located within the watershed do not discharge with sufficient frequency or duration to cause an impairment in the lake.

**Nonpoint Sources:** Siltation loading comes ~~predominantly~~ exclusively from nonpoint sources. Given the runoff characteristics of the watershed, overland runoff can easily carry sediment into the lake. The Load Allocation will be set at 220,000 tons per year, a 30 percent reduction from the initial sediment loading seen between 1981-1989.

**Defined Margin of Safety:** Because of the unknown relationship between actual sediment loading and resulting in-lake water clarity and because the annual loading rate will vary greatly over time, the Margin of Safety will be implicit based on the assumption that watershed treatment will effect a 30% reduction over the long term, but will be more effective during the moderate or low rainfall years and this should offset the occasional major runoff event. Furthermore, because it is likely the lake has not endured constant loading since 1989 at the 250 acre-feet rate seen from 1981-1989, the current lake storage is likely to be in better condition than what is presupposed under this TMDL.

**State Water Plan Implementation Priority:** Because El Dorado Lake is a federal reservoir with a small watershed and a large regional benefit for recreation and water supply, this TMDL will be a High Priority for implementation.

**Unified Watershed Assessment Priority Ranking:** This watershed lies within the Upper Walnut (HUC 8: 11030017) with a priority ranking of 44 (Medium Priority for restoration).

**Priority HUC 11s:** The watershed is within HUC 11 (030). The Walnut River subwatershed should take priority. Secondary focus should be placed the Bemis Creek subwatershed, and tertiary focus should be placed the Satchel Creek subwatershed.



## **5. IMPLEMENTATION**

### **Desired Implementation Activities**

There is a very good potential that agricultural best management practices will improve the water quality in El Dorado Lake. Some of the recommended agricultural practices are as follows:

1. Maintain conservation tillage and contour farming to minimize cropland erosion.
2. Install grass buffer strips along streams.
3. Reduce activities within riparian areas.

Additionally, plans for reassessing the conservation pool after 2010 should be made to reclaim storage lost to sediment.

### **Implementation Programs Guidance**

#### **Nonpoint Source Pollution Technical Assistance - KDHE**

- a. Support Section 319 demonstration projects for reduction of sediment runoff from agricultural activities as well as nutrient management.
- b. Provide technical assistance on practices geared to establishment of vegetative buffer strips.
- c. Update and implement nutrient and sediment abatement strategies.
- d. Develop a Watershed Restoration and Protection Strategy for HUC 11030017.

#### **Butler County Conservation District**

- a. Continue to educate residents and landowners about nonpoint source pollution.

#### **Water Resource Cost Share and Nonpoint Source Pollution Control Program - SCC**

- a. Apply conservation farming practices, including terraces and waterways, sediment control basins, and constructed wetlands.
- b. Provide sediment control practices to minimize erosion and sediment and nutrient transport.

#### **Riparian Protection Program - SCC**

- a. Establish or reestablish natural riparian systems, including vegetative filter strips and streambank vegetation.
- b. Develop riparian restoration projects.

#### **Buffer Initiative Program - SCC**

- a. Install grass buffer strips near streams.
- b. Leverage Conservation Reserve Enhancement Program to hold riparian land out of production.

#### **Extension Outreach and Technical Assistance - Kansas State University**

- a. Educate agricultural producers on sediment, nutrient, and pasture management.

- b. Provide technical assistance on buffer strip design and minimizing cropland runoff.
- c. Continue to educate residents and landowners about nonpoint source pollution.

**Reservoir Management Program - KWO**

- a. Coordinate a comprehensive bathymetric survey of the lake by 2010 with the Tulsa District, Corps of Engineers
- b. Initiate planning for a reservoir pool raise after 2010 to reclaim conservation storage lost to sediment which was to have deposited in the flood control storage.

**Time Frame for Implementation:** Pollutant reduction practices should be installed within the priority subwatersheds during the years 2002-2007, with minor followup implementation, including other subwatersheds over 2007-2011.

**Targeted Participants:** Primary participants for implementation will be agricultural producers within the drainage of the lake. Initial work in 2002 should include local assessments by conservation district personnel and county extension agents to locate within the lake drainage:

- 1. Total row crop acreage
- 2. Cultivation alongside lake

**Milestone for 2007:** The year 2007 marks the midpoint of the ten-year implementation window for the watershed. At that point in time, sampled data from El Dorado Lake should indicate evidence of reduced siltation rates in the conservation pool elevations relative to the conditions seen over 1987-1999.

**Delivery Agents:** The primary delivery agents for program participation will be conservation districts for programs of the State Conservation Commission and the Natural Resources Conservation Service. Producer outreach and awareness will be delivered by Kansas State Extension and the Butler County Conservation District.

**Reasonable Assurances:**

**Authorities:** The following authorities may be used to direct activities in the watershed to reduce pollutants.

- 1. K.S.A. 65-171d empowers the Secretary of KDHE to prevent water pollution and to protect the beneficial uses of the waters of the state through required treatment of sewage and established water quality standards and to require permits by persons having a potential to discharge pollutants into the waters of the state.
- 2. K.S.A. 2-1915 empowers the State Conservation Commission to develop programs to assist the protection, conservation and management of soil and water resources in the state, including riparian areas.

3. K.S.A. 75-5657 empowers the State Conservation Commission to provide financial assistance for local project work plans developed to control nonpoint source pollution.
4. K.S.A. 82a-901, et seq. empowers the Kansas Water Office to develop a state water plan directing the protection and maintenance of surface water quality for the waters of the state.
5. K.S.A. 82a-951 creates the State Water Plan Fund to finance the implementation of the *Kansas Water Plan*.
6. The *Kansas Water Plan* and the Walnut Basin Plan provide the guidance to state agencies to coordinate programs intent on protecting water quality and to target those programs to geographic areas of the state for high priority in implementation.

**Funding:** The State Water Plan Fund annually generates \$16-18 million and is the primary funding mechanism for implementing water quality protection and pollutant reduction activities in the state through the *Kansas Water Plan*. The state water planning process, overseen by the Kansas Water Office, coordinates and directs programs and funding toward watersheds and water resources of highest priority. Typically, the state allocates at least 50% of the fund to programs supporting water quality protection. This watershed and its TMDL are a High Priority consideration.

**Effectiveness:** Sediment control has been proven effective through conservation tillage, contour farming, and use of grass waterways and buffer strips. The key to success will be widespread utilization of conservation farming within the watersheds cited in this TMDL.

## 6. MONITORING

Additional data, to establish sediment loading and further determine mean summer lake trophic condition, would be of value prior to 2007. Further sampling and evaluation should occur once before 2007 and twice between 2007 and 2011. Some monitoring of tributary levels of sediment will help direct abatement efforts toward major contributors. A sediment-bathymetric survey of the lake should be conducted before 2010 to ascertain the available storage in the conservation pool.

## 7. FEEDBACK

**Public Meetings:** Public meetings to discuss TMDLs in the Walnut Basin were held January 10 and March 7, 2002 in Augusta. An active Internet Web site was established at <http://www.kdhe.state.ks.us/tmdl/> to convey information to the public on the general establishment of TMDLs and specific TMDLs for the Walnut Basin.

**Public Hearing:** A Public Hearing on the TMDLs of the Walnut Basin was held in Augusta on June 5, 2002.

**Basin Advisory Committee:** The Walnut Basin Advisory Committee met to discuss the TMDLs in the basin on October 4, 2001, January 10, March 7, and June 5, 2002.

**Discussion with Interest Groups:** Meetings to discuss TMDLs with interest groups include:  
Kansas Farm Bureau: February 27 in El Dorado  
Walnut Basin Ecosystem Restoration Feasibility Study Meetings in Whitewater, Winfield, and Augusta

**Milestone Evaluation:** In 2007, evaluation will be made as to the degree of implementation which has occurred within the watershed and current condition of El Dorado Lake. Subsequent decisions will be made regarding the implementation approach and follow up of additional implementation in the watershed.

**Consideration for 303(d) Delisting:** The lake will be evaluated for delisting under Section 303(d), based on the monitoring data over the period 2007-2011. Therefore, the decision for delisting will come about in the preparation of the 2012 303(d) list. Should modifications be made to the applicable water quality criteria during the ten-year implementation period, consideration for delisting, desired endpoints of this TMDL and implementation activities may be adjusted accordingly.

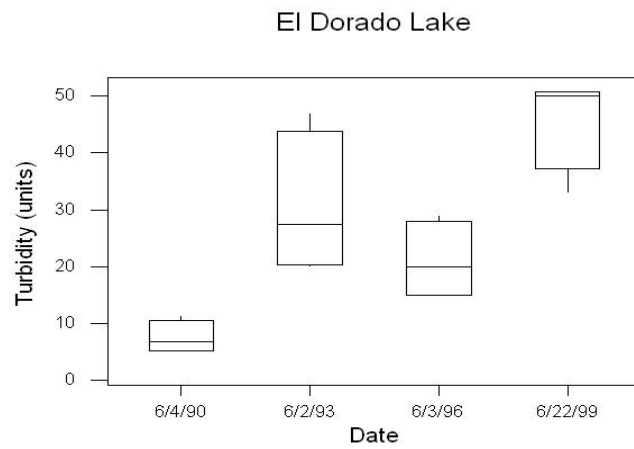
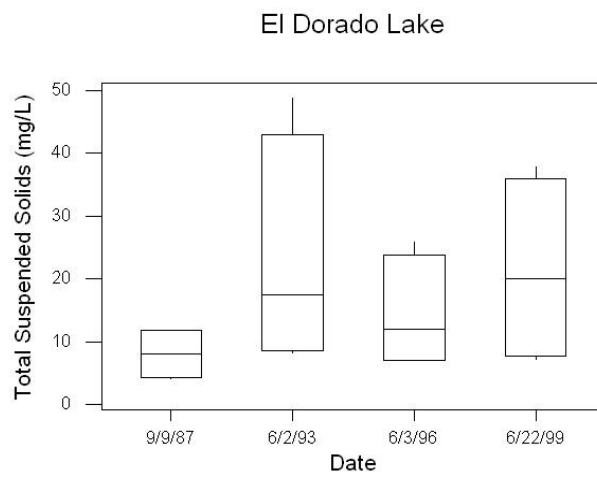
**Incorporation into Continuing Planning Process, Water Quality Management Plan and the Kansas Water Planning Process:** Under the current version of the Continuing Planning Process, the next anticipated revision will come in 2003 which will emphasize revision of the Water Quality Management Plan. At that time, incorporation of this TMDL will be made into both documents. Recommendations of this TMDL will be considered in *Kansas Water Plan* implementation decisions under the State Water Planning Process for Fiscal Years 2003-2007.

## **Bibliography**

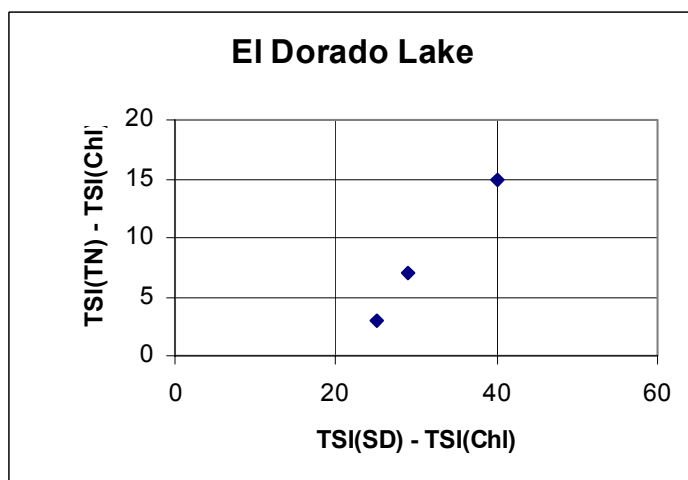
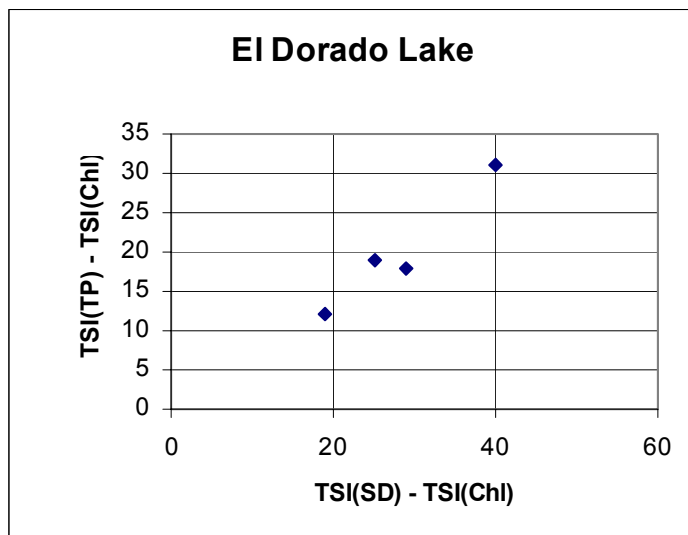
Lim, Niang Choo. "Assessment of Reservoir Water Quality and Its Application to Reservoir Management in the Central Plains." Thesis. University of Kansas. 2001.

Liscek, Bonnie C. Methodology Used in Kansas Lake TMDLs [web page] Jul. 2001;  
<http://www.kdhe.state.ks.us/tmdl/eutro.htm> [Accessed 17 May 2002].

## Appendix A - Boxplots



## Appendix B - Trophic State Index Plots



The Trophic State Index plots indicate that light is the primary limiting factor, due to clay turbidity. This is inferred by examining the relationship between the TSI(SD) - TSI(Chl) and TSI(TP)-TSI(Chl) or TSI(TN)-TSI(Chl). The deviation of chlorophyll from the sediment load indicates the degree of light penetration, while the difference between chlorophyll and phosphorus, or chlorophyll and nitrogen indicates the level of phosphorus or nitrogen limitation. Therefore, if the final plot is in the first quadrant, it shows that the transparency of the water is impaired due to the presence of small particles, and that phosphorus and nitrogen do not limit algae growth. The positive slope of the graph also indicates a correlation between phosphorus and transparency which is found when phosphorus is bound to non algal particles.

Approved September 30, 2002